A Study on the Color Modelling Method for Color Picture Tube Color Display

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ABSTRACT

Color pictures on CPT are generally affected by the receiver characteristic and the condition of exterior illuminants. Moreover, readjustment of incorrect color in the CPT causes color distortion on a given picture.

This paper describes a color adjustment method for modelling of CPT at the view point of observer in the ordinary lighting condition. To develop this method, we proposed ways of luminance recompensation under the gamma transformation for the intensity of illuminant, hue/saturation compensation for the types of illuminant and control of specific color for the reference.

Based on these method, a color correlation system is suggested with the goal of reducing the color errors which are represented due to the influence of reflectance component of illuminants, the gamma transformation of CPT and the frequently adjustment of reference scene to set a optimum color.

CPT 색제시를 위한 색모델링 방법 연구

이 응 주[†]

요 약

일반적으로 CPT에 재현되는 칼라영상은 수상기의 특성이나 외부광원에 의하여 영향을 받으며 CPT에 재현되는 부정확한 칼라의 조정은 주어진 영상의 색 왜곡을 발생시킨다. 본 논문에서는 일상적인 광원 환경 아래 시청자들의 측면에서 CPT에 재현되는 색의 모델링을 위한 색 조정 방법을 기술하였다. 이를 위하여 본 논문에서는 광원의 세기에 따른 감마 보정 상태에서의 휘도 보상 방법, 광원의 종류에 따른 색상 및 색농도 보상 방법 및 기준색 설정을 위한 특정색 조정 방법을 제안하였다. 제안한 방법에 근거하여 광원의 반사 성분의 영향과 CPT의 감마변환 및 최적의 색 설정을 위한 기준 장면 조정시 발생될 수 있는 색 오차를 감소시키는 색 보상 시스템 구현 방법을 제안하였다.

1. Introduction

Color is one of the important factors to determine the quality of an image and color display technology of CPT has been improved significantly. However, the color image on CPT has been somewhat distorted due to the other factors such as gamma correction at the receiver side, the influence of exterior illuminant[1] and the control of specific reference color[2-3]. It pays to remind ourselves that we cannot truly watch color picture on CPT because of these factors.

In conventional TV system, before conversion from the RGB signal to YIQ signal, non-linear processing to compensate the transfer characteristic of the color picture tube, called gamma correction, is applied to the RGB signal[4]. Gamma is frequently used for the CPT tone curve characteristic of each channel. Because of the gamma pre-compensation, reproduced luminance signal is degraded by chrominance signal and gain of the luminance signal over cut-off frequency can be

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reduced.

The another problem for reproduction of color on CPT is exterior lighting conditions which affect reproduced colors. Generally, the color coordinates of the reproduced pictures are shifted for the types as well as the intensity of the illuminants. Because human visual system depends on interaction between light and the eye, we have also to consider how exterior illuminant manages to influence color information on CPT.

The color of objects is determined by the spectral distribution of the light the objects emit. When the observer watches color picture on CPT under ordinary environment, the exterior illuminant irradiates on CPT. Thus, the brightness, saturation and the hue of the color picture become changed. From this reason, the color on CPT can be somewhat distorted due to lighting condition at the view point of the color reappearance.

As mentioned above, from the gamma precompensation and the influence of exterior lighting conditions, chromaticity of color pictures on CPT is somewhat distorted. For readjustment of distorted colors on CPT, the viewer can adjust the color control at the receiver, but another changes take place from the unreasonable adjustment. Thus, some form of automatic color control is desirable.

In this paper, we proposed the color modelling method to reproduce the real colors on CPT. For the reappearance of color pictures, we provide the employment of gamma compensation, the compensation method for the condition of exterior illuminants, and the specific color control method for the viewer.

2. Gamma transformation for the intensity of illuminant

Gamma correction is quite different in nature from other color display elements proceeding actual color adjustment. In fact it is a matter of taste whether the selection of gamma should be considered as an color adjustment. Especially, if exterior illuminant irradiate on CPT, the brightness somewhat changes and from the results gamma must be transformed for the intensity of illuminant. Thus, it is necessary to transform automatically the most optimal gamma for each exterior environment.

In TV system, the picture tube is adjusted to produce the desired reference white by a suitable adjustment of the three gain controls and the light intensity in tristimulus values(R, G, B) produced by each beam current, which is power function(λ) of the applied voltage as follows:

$$R = kE_r$$
$$G = kE_g,$$
$$B = kE_b$$

And the respective phosphors produce corresponding luminance Y_r, Y_g, Y_b from the red, green, and blue gun, respectively.

$$Y_r = \alpha E_r$$
$$Y_g = \beta E_g,$$
$$Y_b = \gamma E_b$$

where, $\alpha + \beta + \lambda = 1$ and total luminance Y is the sum of Y_r, Y_g, and Y_b.

However, the reproduced luminance signal is distorted by the interfering signal, which produces frequency difference between color-subcarrier. And also, the reflectance component of illuminant in the ordinary viewing environment causes color difference to the viewers.

Thus, we provide a automatic gamma selection for the intensity of illuminants. Selection of a gamma affects the colors of image. Especially, gamma greatly affects the brightness of an image. If the intensity of illuminants increase, the color coordinate of an image on CPT shifts toward reference white and the brightness of an image increase. Thus, gamma readjustment is necessary before the compensation of color information.

In TV system, when the video signals with

standard NTSC primary were transmitted, the gamma (λ) of CPT is 2.2 and pre-compensation factor at the transmission side is 0.45. Thus, these gamma factors are reduced for the intensity of illuminants as 2.0 or 1.0. If the factors 2.0 is applied to the receiver, compensation circuit can be simplified. And also, the chrominance signal, which produces the three color difference signal, produces no luminance variation in a linear display, that is gamma factor is 1.

The decision procedure of gamma for the intensity of illuminant is as follows:

Compute the Intensity of exterior illuminant
  Select optimal gamma factors
    If (intensity 50 lux with a fluorescent lamp or
        45 lux with a incandescent lamp)
      gamma = 1.0
    else if (30 lux with a fluorescent lamp intensity
        50 lux with a fluorescent lamp) or
        (25 lux with a incandescent lamp intensity
        45 lux with a incandescent lamp)
      gamma = 2.0
    else gamma = 2.2

3. Hue/Saturation correction for the types of illuminants

Frequently, a reproduction of an color image on CPT will differ deliberately from the original because the original and reproduction environment factors have different attributes. Thus, when reproducing a color pictures on CPT, it is often desirable to approach at the sides of chromatic differences within system and visual space for the various factors which affect to visual system.

The goal of CPT color measurement is to determine tristimulus values X, Y, Z, as defined by the CIE in its publications. For exterior illuminant with a spectral energy distribution $\varphi(\lambda)$,

$$X = k\int_{360nm}^{830nm}\varphi(\lambda)\bar{x}(\lambda)d\lambda$$

$$Y = k\int_{360nm}^{830nm}\varphi(\lambda)\bar{y}(\lambda)d\lambda \qquad (1)$$

$$Z = k\int_{360nm}^{830nm}\varphi(\lambda)\bar{z}(\lambda)d\lambda$$

where, k is a constant that depends on the circumstances, and $\bar{x}(\lambda)$, $\bar{y}(\lambda)$, $\bar{z}(\lambda)$, are color matching function. While it is possible to obtain the colorimetric values of pictures by using the spectral reflectance of exterior illuminant and the spectral characteristic of the exterior illuminants.

$$X_e = k\int_{360nm}^{830nm}R(\lambda)\varphi(\lambda)\bar{x}(\lambda)d\lambda$$

$$Y_e = k\int_{360nm}^{830nm}R(\lambda)\varphi(\lambda)\bar{y}(\lambda)d\lambda \qquad (2)$$

$$Z_e = k\int_{360nm}^{830nm}R(\lambda)\varphi(\lambda)\bar{z}(\lambda)d\lambda$$

In this paper, to improve the exact expression and to evaluate the degree of reproduction quality on CPT. CIE Lu 'v' uniform color space is adopted.

The block diagram of the reproduced color on CPT is shown in Fig. 1. A color image on CPT is transformed from the original RGB data into XYZ tristimulus values. However, the spectral reflectance $R_e(\lambda)$ of the exterior illuminant is added on the reproduced image and the chromatic values on CPT is affected. To enhance color picture on CPT, the X'Y'Z' tristimulus value of the reproduced image under a illuminant must be corrected

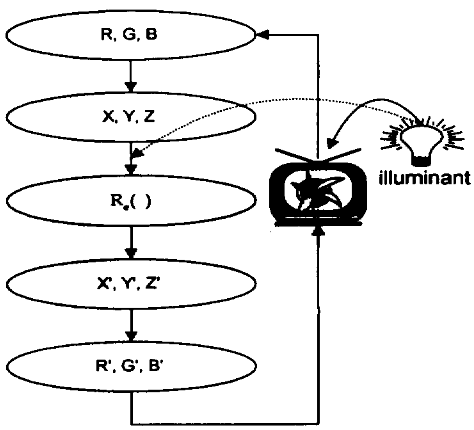


Fig. 1. Diagram of the reproduced color on CPT.

from the spectral reflectance of a exterior illuminant and the spectral radiant distribution of CPT.

If fluorescent irradiate on CPT, the hue value of reproduced color somewhat distorted with bluish-tone. Similarly, the hue value of reproduced color somewhat distorted with redish-tone for the incandescent case, respectively. And also, brightness increase toward white point. Thus, to correct distorted colors, saturation and hue values should be corrected because brightness is corrected in the gamma transformation step.

In this paper, the colorimetric characteristic of the CPT under the exterior illuminant is calculated using spectroradiometer. To discriminate the exterior illuminant and to correct the distorted image on CPT, color sensing circuit[1] was taken. From the chromatic matching between distorted image and original image, correction factors such as R-Y/B-Y, gain, hue, and saturation values in the color control chips are controlled for the illuminant using TV control mode.

4. Reference color control for color measurement

In TV system, the viewer finds that color changes between channels, scenes, or even TV receivers generally require readjustment of the color control [5-9]. However it is unreasonable to expect the viewer to constantly adjust his color control as these changes take place. The viewer does not have a reference color and some colors such as flesh tone, green, and blue are more important than other colors in the determination of reference color. In order to satisfy viewers demand, reference color control algorithm is necessary. Displaying reference colors in a current television system is difficult problem because it has non-linear characteristic of corresponding factors such as viewers demands, human visual characteristic and system characteristic itself.

In TV system, many reference colors can be defined for the viewers, but we used flesh tone for reference. Because flesh is the most critical and common color reference in the color display system that the viewer can rely on. Moreover, the flesh tone has been situated as an important memory color not only in our lives but also in color display systems such as TV[10-11]. The xy color coordinate of flesh tone in actual television system is (0.401, 0.368).

5. Color adjustment diagram for modelling of CPT

The proposed method to describe the modelling of the color reappearance on CPT is shown in Fig. 2. To develop this method, we proposed ways of luminance compensation under the adaptive gamma transformation for the intensity of illuminant, the compensation of lighting influence and the control of specific color.

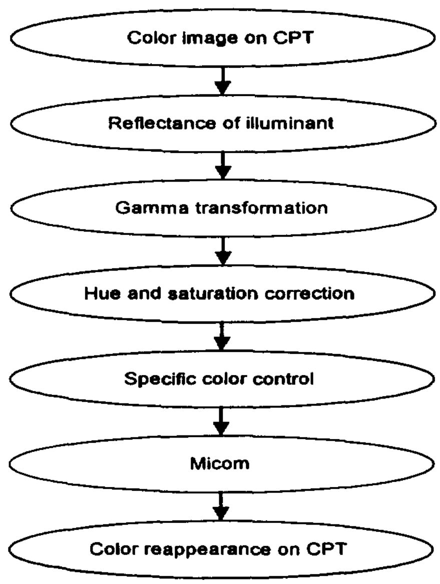


Fig. 2. Color adjustment diagram.

6. Experimental results

In the experiment, we focus on the modelling of

color images reproduced on CPT under the gamma controls and the compensation of hue/saturation for the change of illuminants. Fig. 3 shows the comparison of color errors between distorted and corrected color image on CPT under the exterior illuminants such as incandescent lamp(yellow point : conventional, blue point : proposed) and fluorescent lamp (green point : conventional, red point: proposed) for the intensity level (point 1 : small, point 2 : medium, point 3 : high intensity). Fig 4 shows the uvcolor chromaticity of five skin colors for the selecting of the reference color.

Fig. 5 and Fig. 6 show the photography of real images on CPT from without and with the proposed algorithm. Fig. 5 (a) is the original beautiful girl image reproduced on CPT, Fig. 5 (b) is the resulting image controlled on the gamma (2.0-2.2) and the

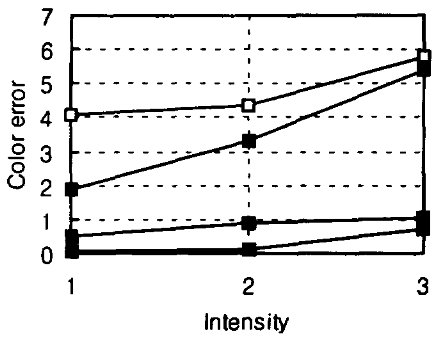


Fig. 3. Comparison of color error between distorted and corrected color image on CPT.

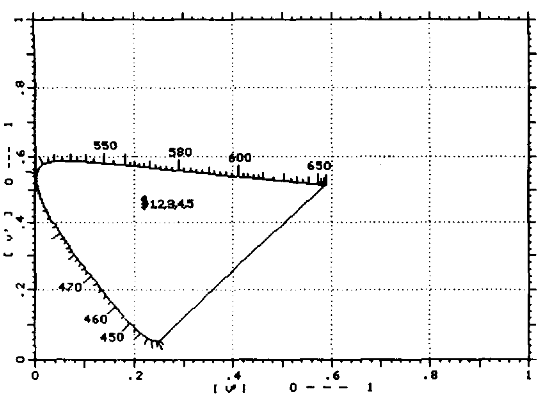
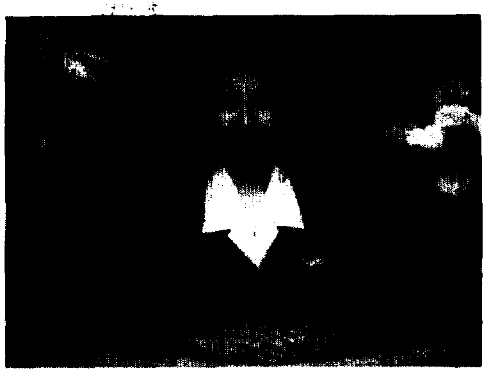
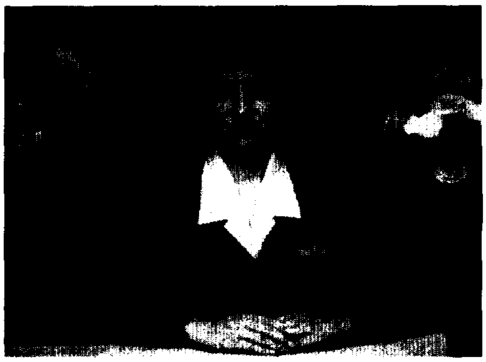


Fig. 4. The uv color chromaticity of skin color.



(a)



(b)

Fig. 5. Comparison of beautiful girl image with red, green and blue signal reproduced on CPT: (a) original image; (b) modelling image.

reference flesh-tone. Fig. 6 (a) is the original beautiful girl image and, Fig. 6 (b) is the resulting image controlled on the gamma (2.0-2.2) and reference red colors. From the result, the modelling color system represent specific colors more vivid than others.

7. Conclusion

This paper describes a method for color adjustment of CPT in the ordinary lighting condition. To develop this method, we proposed ways of luminance recompensation under the gamma transformation for the intensity of illuminant, hue/saturation compensation for the types of illuminant and control method of specific color in CPT for the reference color.

(a)

(b)

Fig. 6. Comparison of beautiful girl image with flowers reproduced on CPT : (a) original image; (b) modelling image.

Based on these method, a color correction system is suggested with the goal of reducing the color errors which are represented due to the influence of illuminants, the gamma transformation of CPT and the frequently adjustment of reference scene to set a reference color.

Reference

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